Vanderbilt University Biostatistics Comprehensive Examination

PhD Applied Exam Series 2

May 27–May 30, 2025

Instructions: Please adhere to the following guidelines:

- This exam is scheduled to be administered on Tuesday, May 27 at 9:00am, and will be due on Friday, May 30 at 5:00pm. This deadline is strict: late submissions will not be accepted.
- To turn in your exam, please use your assigned Box folder and e-mail your exam to Dr. Andrew Spieker by the deadline. This redundancy is designed to ensure that your exam is received by the deadline. If you would like to e-mail exam drafts along the way, that is perfectly acceptable—do not be concerned about spamming my inbox.
- You are advised to pace yourself and to not spend too much time on any one problem. Further, note that there is no one single correct answer to any question on this examination. The questions are open-ended.
- Answer each question clearly and to the best of your ability. Partial credit will be awarded for partially correct answers.
- Be as specific as possible in your responses.
- You may consult reference material (e.g., course notes, textbooks), though the work you turn in must be your own (this means no generative AI). This is an *individual effort*. Do not communicate about the exam with anyone. Vanderbilt University's academic honor code applies.
- Please direct clarifying questions by e-mail to Dr. Andrew Spieker.

Background: Influenza Vaccination

Seasonal influenza vaccination is considered the most effective strategy to reduce the burden of influenza disease. Nevertheless, uptake of influenza vaccination remains sub-optimal, and attitudes regarding influenza vaccination are heterogeneous, particularly in developing countries. This is true even among healthcare providers (HCPs), who ostensibly are better equipped to distinguish between "fact" and "myth" regarding the influenza vaccine. A good step in improving vaccine uptake is to better understand the misconceptions people might be facing about influenza vaccination and who might be facing them. This study is one small step toward that end.

Disclaimer: This data set and the description thereof are motivated by/adapted from real-world studies, but with substantial modification for pedagogical purposes.

Study Background: Influenza Vaccine Attitudes Survey

In the summer of 2024, a survey-based study regarding influenza vaccination was conducted in a developing country to better understand the current state of knowledge among HCPs in that country regarding influenza vaccination. In particular, a survey was sent out to all HCPs employed at a single hospital network in that country via an e-mail blast. Participation was completely voluntary. A response to the survey was only recorded in the system if a respondent completed the entire survey. No record exists of any respondents who began but did not complete the survey. A total of $n = 211$ participants were recorded as having completed the survey; these are provided in the data set you have been supplied (namely, `survey-results.csv`).

The survey components are broken into four main categories. First, participants are queried on their demographics (e.g., age). Next, they are asked questions regarding various aspects of their attitudes on influenza vaccination and asked to respond on a Likert scale of 0-2. Next, respondents are asked what is in some ways the "key question" of the survey: "Have you ever received the influenza vaccine?" Among those who specifically answer "no," the survey then invites them to select among many potential reasons why (all respondents were required to select at least one of the reasons listed).

Study aims

The following questions are intentionally open-ended, with focus on broad scientific goals. Your objective is to thoroughly and carefully answer the questions, taking statistical considerations into account. Again, there is no one single correct answer.

1. How are HCP characteristics associated with their attitudes toward influenza vaccination?
2. How are HCP characteristics associated with their receipt of the influenza vaccine?
3. How are HCP attitudes toward influenza vaccination associated with their receipt of the influenza vaccine?
4. Among HCPs reporting never having received the influenza vaccine, what are their reasons for not doing so?

A reminder to keep your responses guided by and relevant to the questions above.

Exam task and formatting instructions

Your task is to create an analysis report in which you address the scientific questions and summarize your findings. Clearly describe your methods in detail and state assumptions explicitly. Where possible, explore how well those assumptions are met and/or how sensitive the results of your analyses are to important assumptions you make. Describe or address any statistical considerations you would expect to be considered in the peer-review process. While there is no page/word limit, your report should be parsimonious.

Guidance for the analysis report (much of which also applies to your professional practice as a biostatistician)

(1) Pace yourself. Don't begin by running a bunch of models; instead, start by considering the study questions and background. Carefully weigh the advantages and disadvantages of different approaches. No one approach will be perfect, but considering various trade-offs before looking at the data will help you avoid common pitfalls and will leave you better equipped to articulate your reasons for choosing your approach.

(2) The study has limitations that may make it challenging to find the perfect solution to answer the scientific questions as stated. You should do the best you can, but your interpretation of the findings should be stated appropriately. In your discussion, you may want to describe some of these limitations (e.g., key variables omitted from the study) and how they impact your conclusions.

(3) Use clear section and subsection headers to delineate sections (e.g., introduction, methods, results, and discussion) so that so it is easy for the reader to find what they are looking for.

- I recommend beginning with an introduction section. Unlike a research paper, though, an analysis report can include methodology/results/discussion sections laid out *separately* for each question being answered.
- For example, each scientific question likely deserves its own main heading. Subheadings can include a summary of your findings, sections for methods, results, and discussion.
- You don't have to be strict in separating those the way you do in a journal article. For example, you could have a subsection on sensitivity analyses in which you describe the methods and results together in that subsection. Having them together often reads better as long as it's clear when you're reading methods and when you're reading results.

(4) Your goal is to answer the questions the way you would as a practicing statistician; it's not to show off all the methods you know. In fact, a subset of the questions may be better answered with simple descriptive statistics. If you do multiple analyses for a question, be clear which is the main analysis and which are exploratory/confirmatory analyses.

(5) You want your analysis report to be readable by both clinicians and statisticians; you also want to summarize your findings in plain English.

(6) You want to be sufficiently detailed, but not bury the main points between lots of details.

(7) You'll want to make your code available, but you do not want it to clutter up your report. The preferred way to accomplish this is to make it so that you have to click a tab to reveal the code in a .html file report (RStudio notebooks/Quarto); another is to have it as a separate file with clear section headings as comments (knitr .pdf report). **Code should be annotated with comments that are designed to make it clear what the key pieces are doing. Do not assume the reader will be able to figure it out without guidance.**

Codebook

The data set contains the variables listed in the table below.

Variable name	Description
RESPONDENT CHARACTERISTICS:	
`id`*	unique participant ID
`age`	age (years)
`exper`	time of experience in field (years)
`male`	male (0 = no; 1 = yes)
`prof`	professional title (0 = physician; 1 = pharmacist; 2 = other)
`deg`	degree (0 = MD or equivalent; 1 = PhD or equivalent)
QUESTIONS REGARDING ATTITUDE (0 = disagree; 1 = neutral; 2 = agree):	
`hr`	"It is important to vaccinate high-risk individuals."
`benefit`	"The benefits of vaccination outweigh the risks."
`safe`	"Influenza vaccination is safe."
`hcp.vac`	"Healthcare providers should receive the influenza vaccine."
VACCINE RECEIPT:	
`rvac`	"Have you ever received the influenza vaccine?" (0 = no; 1 = yes; 2 = unsure)
IF RESPONDED "NO" TO PREVIOUS QUESTION (0 = unchecked; 1 = checked):	
`no.why.1`	"I do not have time to receive the influenza vaccine."
`no.why.2`	"I've previously gotten sick after receiving the influenza vaccine."
`no.why.3`	"I have concerns about the influenza vaccine's safety."
`no.why.4`	"The influenza vaccine weakens the immune system."
`no.why.5`	"I do not believe the influenza vaccine is effective."
`no.why.6`	"I prefer to fight influenza with natural immunity."
`no.why.7`	"I am not in contact with high-risk patients."
`no.why.8`	"I believe my immune system is sufficiently strong to fight influenza."
`no.why.9`	"I do not want to pay for the influenza vaccine."

* There is one participant with an `id` of "0," corresponding to a test observation that was input by the study's investigative team solely to test the functionality of the electronic survey.

Evaluation

Your exam submission will be evaluated on the following general areas:

- The statistical validity and thoughtfulness of your approach, along with accuracy of implementation.
- How well your responses address the scientific and clinical questions.
- The appropriateness/quality of your writing and presentation.